

--	--	--	--	--	--	--	--	--	--

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 3, 2015/2016

PTH0016 – MODERN PHYSICS & THERMODYNAMICS
(All Sections / Groups)

30 MAY 2016
9.00 A.M – 11.00 A.M.
(2 Hours)

INSTRUCTIONS TO STUDENTS

1. This question paper consists of 9 pages including cover page and appendices with SIX (6) questions only.
2. Attempt **ALL** questions. All questions carry equal marks and the distribution of the marks for each question is given.
3. Please write all your answers in the Answer Booklet provided.
4. All necessary workings **MUST** be shown.

ANSWER ALL QUESTIONS.**QUESTION 1 (10 MARKS)**

- (a) A wire of length 4.35 m and mass 137 g is under a tension of 125 N. A standing wave is formed in the wire which has seven nodes including the endpoints.
- (i) What is the frequency of this wave? [2 marks]
- (ii) What is the fundamental frequency? [1 mark]
- (iii) The maximum amplitude at the antinodes is 0.0075 m, write the equation for this standing wave. [2 marks]
- (b) (i) What is the evidence that sound travels as a wave? [1 mark]
- (ii) An expensive amplifier A is rated at 250 W, while a more modest amplifier B is rated at 40 W. Estimate the sound level in decibels you would expect at a point 3.5 m from a loudspeaker connected in turn to each amplifier. [4 marks]

Continued...

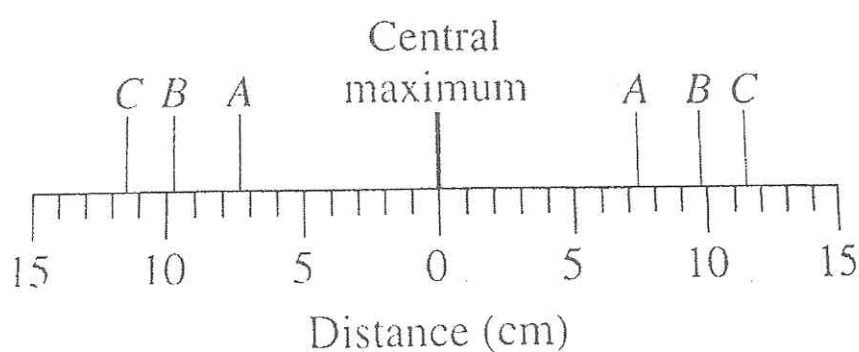
QUESTION 2 (8 MARKS)

- a) A 5.0 cm tall object is placed 50.0 cm to the left of a converging lens with a focal length of 20.0 cm. A convex mirror with a radius of curvature of -25.0 cm is placed 45.0 cm to the right of the lens.
- (i) Calculate the final image distance, measured relative to the mirror. [3 marks]
 - (ii) Determine whether the final image is real or virtual. [0.5 mark]
 - (iii) Calculate the overall magnification. [1.5 marks]
 - (iv) Determine whether the final image is upright or inverted, with respect to the original object. [0.5 mark]
 - (v) Determine whether the final image is smaller, larger or same size, with respect to the original object. [0.5 mark]
- b) A laser beam is travelling through an unknown substance. When it encounters a boundary with air, the angle of reflection is 37.5° and the angle of refraction is 44.3° .
- (i) Calculate the index of refraction of the unknown substance. [1 mark]
 - (ii) At what minimum angle of incidence would the light of the laser beam be totally internally reflected? [1 mark]

Continued...

QUESTION 3 (8 MARKS)

- a) You are given a slide with two slits cut into it. You shine white light on the slide and notice the second-order color spectrum that is created on a screen 4.0 m away. On the screen, the red light with a wavelength of 700 nm is separated from the violet light with a wavelength of 400 nm by 8.33 mm. Determine the separation of the two slits. [3.5 marks]
- b) A reflection grating spectrometer is used to view the spectrum of light from a helium discharge tube. The three brightest spectral lines seen are red, yellow, and blue in color. These lines appear at the positions labeled *A*, *B*, and *C* as shown in **Figure Q3(b)**, though not necessarily in that order of color. In this spectrometer, the distance between the grating and slit is 25.0 cm and the slit spacing in the grating is 1750 nm.

**Figure Q3(b)**

- (i) Identify which is the red, yellow, and blue line. [1.5 marks]
- (ii) Calculate the wavelength of spectral line *C*. [2 marks]
- (iii) Determine the highest order of spectral line *C* that is possible to see using this grating. [1 mark]

Continued...

QUESTION 4 (8 MARKS)

- a) Two different monochromatic light sources, one green (570 nm) and one violet (425 nm), are used in a photoelectric effect experiment. The metal surface has photoelectric threshold frequency of 6.2×10^{14} Hz.
- (i) Calculate the frequency of light from each light source. [2 marks]
 - (ii) Determine whether both sources are able to eject photoelectrons from the metal. Explain your answer. [1.5 marks]
 - (iii) Calculate the amount of energy required to eject an electron from the metal surface in eV. [1 mark]
- b) An electron emits a photon of energy 1.3 eV when it makes a transition from the first excited state to the ground state in an atom.
- (i) Calculate the ground-state energy (in eV) of the electrons. [1 mark]
 - (ii) Calculate all energies (in eV) of photons that could be emitted when the electron starts in its second excited state and makes transitions downward to the ground state either directly or through intervening states. Then, show by sketching all these transitions on an energy level diagram. [2.5 marks]

Continued...

QUESTION 5 (8 MARKS)

- (a) Can hydrogen or deuterium emit an α particle? Explain [3 marks]
- (b) $^{124}_{55}\text{Cs}$ has a half-life of 30.8 s.
- (i) If we have 8.8 μg initially, how many Cs nuclei are present? [1.5 marks]
- (ii) How many nuclei are present 2.0 min later? [2.5 marks]
- (iii) What is the activity at 2.0 min ? [1 mark]

QUESTION 6 (8 MARKS)

- (a) The heat capacity, C , of an object is defined as the amount of heat needed to raise its temperature by 1°C . Thus, to raise the temperature by ΔT requires heat Q given by
- $$Q = C \Delta T$$
- (i) Write the heat capacity in terms of the specific heat, c , of the material. [2 marks]
- (ii) What is the heat capacity of 1.0 kg of water? [1 mark]
- (iii) What is the heat capacity of 25.0 kg of water? [1 mark]
- (b) Water with mass of 2.0 kg is held at constant volume in a container while 10.0 kJ of energy is slowly added by a flame. The container is not well insulated, and as a result 2.0 kJ of energy leaks out to the surroundings. What is the temperature increase of the water? [4 marks]

End of Paper.

APPENDIX I

LIST OF PHYSICAL CONSTANTS

Electron mass,	m_e	=	$9.11 \times 10^{-31} \text{ kg}$
Proton mass,	m_p	=	$1.67 \times 10^{-27} \text{ kg}$
Neutron mass,	m_n	=	$1.67 \times 10^{-27} \text{ kg}$
Magnitude of the electron charge,	e	=	$1.602 \times 10^{-19} \text{ C}$
Universal gravitational constant,	G	=	$6.67 \times 10^{-11} \text{ N.m}^2 / \text{kg}^2$
Universal gas constant,	R	=	8.314 J/mol.K
Hydrogen ground state,	E_0	=	13.6 eV
Boltzmann's constant,	k_B	=	$1.38 \times 10^{-23} \text{ J/K}$
Compton wavelength,	λ_c	=	$2.426 \times 10^{-12} \text{ m}$
Planck's constant,	h	=	$6.63 \times 10^{-34} \text{ J.s}$
		=	$4.14 \times 10^{-15} \text{ eV.s}$
Speed of light in vacuum,	c	=	$3.0 \times 10^8 \text{ m/s}$
Rydberg constant,	R_H	=	$1.097 \times 10^7 \text{ m}^{-1}$
Acceleration due to gravity of earth,	g	=	9.80 m/s^2
Unified atomic mass unit,	1 u	=	$931.5 \text{ MeV}/c^2$
		=	$1.66 \times 10^{-27} \text{ kg}$
1 electron volt,	1 eV	=	$1.60 \times 10^{-19} \text{ J}$
Avogadro's number,	N_A	=	$6.023 \times 10^{23} \text{ mol}^{-1}$
Threshold of intensity of hearing,	I_0	=	$1.0 \times 10^{-12} \text{ W/m}^2$
Coulomb constant,	$k = \frac{1}{4\pi\epsilon_0}$	=	$9.0 \times 10^9 \text{ N.m}^2 / \text{C}^2$
Permittivity of free space,	ϵ_0	=	$8.85 \times 10^{-12} \text{ C}^2 / \text{N.m}^{-2}$
Permeability of free space,	μ_0	=	$4\pi \times 10^{-7} \text{ T.m/A}$
1 atmosphere pressure,	1 atm	=	$1.0 \times 10^5 \text{ N/m}^2$
		=	$1.0 \times 10^5 \text{ Pa}$
Wien's displacement constant		=	$0.2898 \times 10^{-2} \text{ m.K}$
Speed of Sound in Air		=	343 m/s
Refractive index of air/vacuum	n	=	1.0
Earth: Mass,	M_E	=	$5.97 \times 10^{24} \text{ kg}$
Radius (mean),	R_E	=	$6.38 \times 10^3 \text{ km}$
Moon: Mass,	M_M	=	$7.35 \times 10^{22} \text{ kg}$
Radius (mean),	R_M	=	$1.74 \times 10^3 \text{ km}$
Sun: Mass,	M_S	=	$1.99 \times 10^{30} \text{ kg}$
Radius (mean),	R_S	=	$6.96 \times 10^5 \text{ km}$
Earth-Sun distance (mean),		=	$149.6 \times 10^6 \text{ km}$
Earth-Moon distance (mean),		=	$384 \times 10^3 \text{ km}$

APPENDIX II

LIST OF FORMULAS IN MODERN PHYSICS & THERMODYNAMICS

$$\sin \theta_1 + \sin \theta_2 = 2 \sin \left(\frac{\theta_1 + \theta_2}{2} \right) \cos \left(\frac{\theta_1 - \theta_2}{2} \right)$$

$$\cos \theta_1 + \cos \theta_2 = 2 \cos \left(\frac{\theta_1 + \theta_2}{2} \right) \cos \left(\frac{\theta_1 - \theta_2}{2} \right)$$

$$\sin \left(\theta + \frac{\pi}{2} \right) = \cos \theta$$

$$\sin \theta \approx \tan \theta \approx \theta \text{ rad for small angles}$$

$$D(x, t) = D_M \sin(kx \pm \omega t \pm \phi)$$

$$v = \sqrt{\frac{F_T}{\mu}} \quad v = \sqrt{\frac{\text{elastic property of the medium}}{\text{inertia property of the medium}}} \quad v = (331 + 0.60 T) \quad v = f\lambda$$

$$f_n = \frac{nv}{2L} \quad f_n = \frac{nv}{4L} \quad \lambda_n = \frac{2}{n}L \quad f' = f \left(\frac{v \pm v_o}{v \mp v_s} \right)$$

$$\frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f} \quad \frac{1}{f} = (n - 1) \left\{ \frac{1}{R_1} + \frac{1}{R_2} \right\} \quad f = \frac{R}{2}$$

$$d \sin \theta = m\lambda \quad d \sin(\theta) = \left(m + \frac{1}{2} \right) \lambda \quad a \sin(\theta) = n\lambda$$

$$\lambda_m T = 0.2898 \times 10^{-2}$$

$$I(\lambda, T) = \frac{2\pi c k_B T}{\lambda^4}$$

$$E_n = -\frac{mk^2 e^4}{2\hbar^2} \left(\frac{1}{n^2} \right) \quad r_n = \frac{\hbar^2}{mke^2} n^2 \quad L = mvr_n = n\hbar$$

$$\frac{1}{\lambda} = R_H \left[\frac{1}{n_i^2} - \frac{1}{n_f^2} \right] \quad \frac{1}{\lambda} = \frac{mk^2 Z^2 e^4}{4\pi c \hbar^3} \left[\frac{1}{n_f^2} - \frac{1}{n_i^2} \right] \quad \lambda = \frac{h}{p}$$

$$R = R_0 e^{-\lambda t} \quad \lambda = \frac{\ln 2}{T_{1/2}} \quad Q = (M_X - M_Y - M_\alpha) c^2$$

$$pV = nRT \quad k = \frac{R}{N_A} \quad N = N_0 e^{-\lambda t}$$

$$\frac{\Delta Q}{\Delta t} = -kA \frac{\Delta T}{\Delta L} \quad \frac{\Delta Q}{\Delta t} = e\sigma A T^4 \quad \frac{\Delta Q}{\Delta t} = IeA \cos(\theta)$$

$$\overline{KE} = \frac{1}{2} m \bar{v}^2 = \frac{3}{2} kT \quad U = \frac{3}{2} nRT$$

$$Q = \Delta U + W \quad W = \int dW = \int_{V_i}^{V_f} P dV \quad W = P \Delta V$$

APPENDIX III

